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Evidence for Stratospheric Downwelling Associated with High-Elevation Topography

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Abstract
The continued presence of elevated chlorine-36 in Sierra Nevada streams is commonly interpreted as residual nuclear fallout, but this prolonged storage contradicts accepted hydrologic models, which indicate much less short-term groundwater storage. Our hypothesis is that the chlorine-36 source is stratospheric downwelling during high-intensity storms by measuring beryllium-7 and -10, sodium-22, and chlorium-36 in precipitation, lake, and soil samples. These nuclides are produced in abundance in the stratosphere and, except for chlorine-36, did not occur as nuclear fallout. This project will either substantially change hydrologic models or reveal an unrecognized pathway for stratosphere–troposphere exchange. Either result will have substantial scientific impact. The test of the hypothesis is straightforward. If stratospheric downwelling occurs to the extent indicated by observed Sierran chlorine-36 levels, it should be detectable by elevated levels of beryllium-7 and -10, sodium-22, and chlorine-36 in storm precipitation. Samples will be collected from an established array of sampling locations. If elevated levels of these nuclides are not found, it would cast severe doubt on the hypothesis. In this case, Sierran hydrologic models will have to take into account high levels of long-term groundwater storage. If elevated levels of these nuclides are found in Sierran precipitation, it could only be from stratospheric input, both because nuclear fallout is no longer occurring and because beryllium-7 and -10 and sodium-22 are not produced by atmospheric nuclear tests.

Mission Relevance
This project supports the Laboratory's national security mission because of its relevance to atmospheric dispersal monitoring for nuclear and other releases. The work also supports the environmental-management mission areas of atmospheric and climate modeling and atmospheric protection from ozone-depleting and greenhouse gases. An ability to characterize certain types of stratosphere–troposphere exchange pathways using relatively inexpensive ground level measurements, as opposed to airborne tropopause measurements, would enhance LLNL's capabilities for testing regional atmospheric and climate models.

Accomplishments and Results
For this project we installed, monitored and collected precipitation samples from a network of precipitation samplers in collaboration with colleagues from University of California at Merced and the U.S. Geological Survey. We collected stream and lake samples to monitor the relationship between precipitation input and elevated chlorine-36 levels. We conducted monitoring of high-elevation lakes and streams and determined isotopic tracers including chlorine-36 in rainwater, snow, lake, and stream and soil samples. We began compilation /interpretation of the results and drawing conclusions about the validity of the downwelling hypothesis and will present the results and conclusions at a future Hydroclimate Conference.

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